Draft: Not for citation without the authors' consent

Mathematics and physics participation in the UK: Influences based on analysis of national survey results[1]

Paper presented at

BERA Symposium – Paper 1 of 3

Saturday, 4th September 2010

Tamjid Mujtaba, Celia Hoyles, Michael Reiss, Fani Stylianidou & Bijan Riazi-Farzad

Institute of Education, University of London

t.mujtaba@ioe.ac.uk

[1] Developed from the Understanding Participation rates in post-16 Mathematics And Physics (UPMAP) project, funded by the Economic and Social Research Council, grant RES-179-25-0013.

1 Introduction

The UPMAP project set out to explore the student and school factors that shape the engagement of students in the UK with mathematics and physics post-16. The project comprises three inter-related strands. **Strand 1 maps trajectories of engagement and disenchantment**, using school and student (Years 8 and 10) surveys, undertaken with the same students. **Strand 2 investigates subjectivities and school culture** by focusing on twelve of the Strand 1 schools in more depth. **Strand 3 documents the reasons for HE choices** by examining the factors that influence subject choices among first year undergraduates.

This paper presents the findings from Strand 1 analyses of responses to phase 1 of the Year 10 (aged 14-15 years) student questionnaires and associated school questionnaires from schools in England. The sample on which we undertook analyses comprised 10,355 students in 120 secondary schools. The schools sampled are, on average, more affluent than is typical in England, with higher attaining students and above average post-16 participation rates in mathematics and physics. This bias was intentional because, although barriers to participation are important, we are particularly interested in factors that affect the 'choices' of those students who have the opportunity (including attainment criteria) to study mathematics or physics post-16. Therefore, we asked our sample schools to administer the questionnaires to those students whom they considered likely to achieve GCSE grades A*-D in mathematics and physics/science. Such a sample will have a bearing on the types of associations we find and report.

In order to explore our overarching research questions we made use of England's National Pupil Database (NPD) and Pupil Level Annual School Census (PLASC) by matching these records onto our survey data. These datasets were given to the team by the DCSF (Department for Children, Schools and Families), now DfE (Department for Education). We currently have a considerable volume of information and the results here present initial analyses on some of these data. The PLASC and NPD datasets hold information on students' attainment records at ages 7 and 11, as well as various background details on students such as gender, eligibility for free school meals (FSMs) and ethnicity. We have also collected further information from our own school questionnaire and the PLASC data on individual schools. We will be following up this work with further surveys in autumn 2010 for the original year 10 cohort (will be year 12 for those students still in education) and original year 8 cohort (will be year 10) with the same sample of schools and students (so far as possible). Thus, further analysis in a year's time will enable UPMAP to explore the impact of within-school variation on students' actual post-16 participation in mathematics and physics. With our phase 1 survey, we were able to match 3000 students, from either the year 8 or the year 10 cohorts, who filled out both the mathematics and physics surveys. We will thus be conducting further analysis that looks at the cross relationship between the mathematics and physics survey answers for this sub-sample of students.

2 Methodology

2.1 The Instruments

The student questionnaires

Student questionnaires were designed following a review of the literature considering factors that may influence post-compulsory participation rates. Alongside questions related to intentions to continue to study mathematics and physics post-16, the survey included items to assess attitudes to each subject and to school and teachers, as well as more general potential influences on participation, such as social capital, engagement in extra-curricular activities, intrinsic and extrinsic motivation for learning, engagement with ICT, personality constructs and family support for studying maths or physics. In addition, we included items in what we term ‘core conceptual areas’ in mathematics and in physics in order to assess attainment and confidence. Some of the questionnaire constructs used items previously established in the relevant research literature; other constructs were derived in discussions amongst the project team members, informed by literature review and team expertise. Cronbach’s alpha was used to assess the internal consistency of all constructs.

The school questionnaires

School surveys were designed to probe school- or department-level factors that might influence post-16 participation in mathematics and physics. Questions sought to collect information on: the department’s policies in relation to promoting post-16 participation; the expertise and resources of the staff; activities put in place to boost engagement in the subject through, for example, extra-curricular activities; and practices in relation to student grouping; deployment of staff with different groups; and examination criteria for continuation with the subject. Two school questionnaires (one on physics/science and one on mathematics) were devised, piloted and distributed to the heads of the physics/science and mathematics departments in the sample schools. Other issues that we will explore are the effects on students’ intended participation of: 11-16/11-18 schools; proportion of specialist maths/physics teachers; and maths/physics teacher turnover.

2.2 The school sample

To give an overall feel for the intake of our school sample, Table 1 displays the percentage of schools (who returned year 10 mathematics and/or physics surveys) that fell within various FSM categories. We obtained school level FSM data from the DCSF. Based on their students’ eligibility for free school meals, the DCSF (now DfE) categorises schools into eight bands. These bands can be used as indices of the socio-economic status of the schools’ student intake. Table 1 indicates that a third of our sample of schools contain very affluent student samples (0-5% FSM) and taking the 5-9% group into the equation we find that over half of our sample of schools serve students from affluent backgrounds.

Table 1: The distribution of UPMAP schools across the FSM school bands

	FSM school bands							
	Most affluent				*Least affluent*			
	0-5%	5-9%	9-13%	13-21%	21-35%	35-50%	50%+	Grammar (in the 0-5% FSM band)
n	25	27	17	19	12	4	2	14
%	20.8	22.5	14.2	15.8	10.0	3.3	1.7	11.7

N = 120 unique schools (i.e. schools where we received questionnaires for mathematics or physics or both).

3 *Findings*

3.1 Related to school FSM bands

Figure 1 and Table 2 displays the mean result of intention to participate by FSM band. These data show that that intention to participate is more or less independent of a school's FSM status and that, regardless of the affluence of the school community, the percentage of students who indicate an intention to participate in mathematics studies post-16 is consistently higher than for physics.

Figure 1: Intention to participate as a function of FSM band of school, shown separately for mathematics and physics (data taken from Table 2)

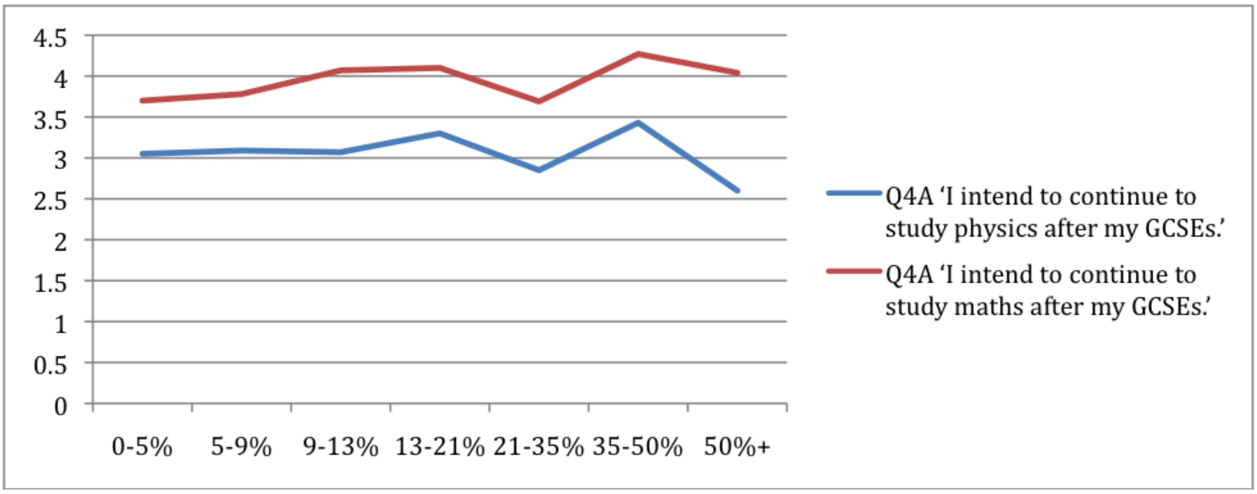


Table 2: The mean result of intention to participate within FSM school groupings (scale goes from 1, strongly disagree, to 6, strongly agree)

	FSM school band							
	Most affluent				Least affluent			
	0-5%	5-9%	9-13%	13-21%	21-35%	35-50%	50%+	Grammar (in the 0-5 FSM)
Q4A 'I intend to continue to study **physics** after my GCSEs.'	3.05	3.09	3.07	3.30	2.85	3.43	2.60	3.05
Q4A 'I intend to continue to study **maths** after my GCSEs.'	3.70	3.78	4.07	4.10	3.69	4.27	4.04	3.99

Tables 3 and 4 show how students within schools in the different FSM bands responded as learners of mathematics and learners of physics.

Table 3: Mathematics Year 10 (England) student mean response per construct for different FSM bands

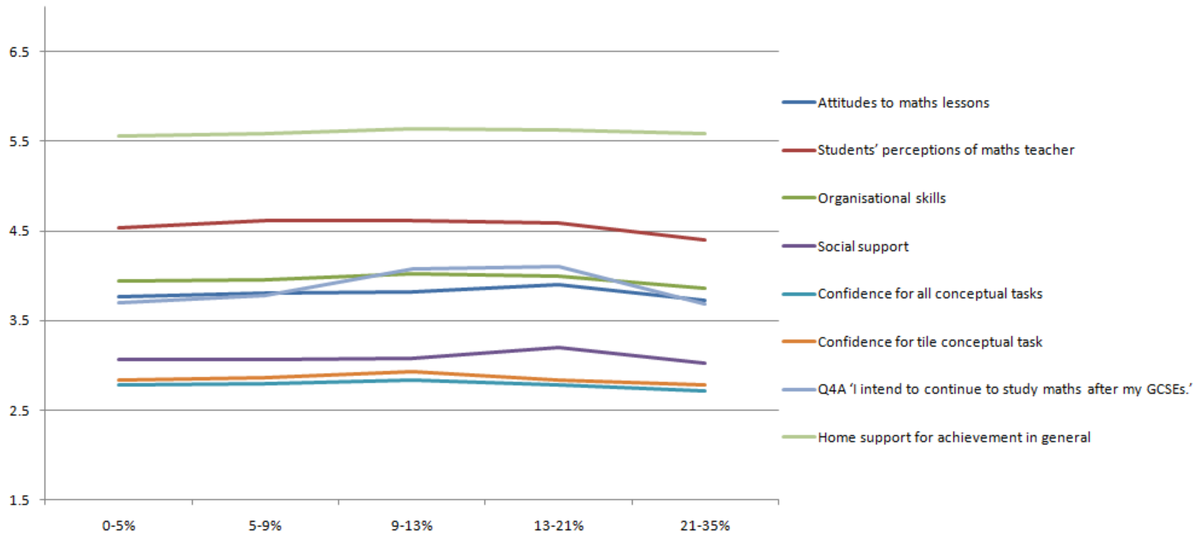
Mean results by construct (scale of 1-6) with 6 being high agreement	School FSM band							
	0-5%	5-9%	9-13%	13-21%	21-35%	35-50%	50%+	Grammar
Mathematics self-concept	3.71	3.71	3.88	3.94	3.81	4.02	3.51	3.73
Perception of maths lessons	3.93	3.96	4.06	4.05	3.86	4.16	4.12	4.07
Attitudes to maths lessons	3.76	3.80	3.82	3.90	3.72	4.02	3.97	3.90
Advice/pressure to study maths	3.96	4.00	4.19	4.17	4.03	4.62	4.26	4.25
Intrinsic perceived value of maths	3.74	3.74	3.83	3.86	3.80	4.24	4.05	3.80
Extrinsic perceived value of maths	3.89	3.90	4.03	4.04	3.96	4.38	4.25	3.88
Students' perceptions of maths teacher	4.53	4.62	4.62	4.59	4.40	4.70	4.77	4.62
Organisational skills	3.94	3.95	4.02	3.99	3.86	4.27	3.88	4.14
Engagement with ICT	3.53	3.65	3.55	3.63	3.65	3.77	3.48	3.52
Global motivations and aspirations	4.56	4.57	4.61	4.71	4.58	5.01	4.67	4.63
Sense of school belonging	4.25	4.17	4.20	4.34	4.29	4.64	4.32	4.44
Home support for achievement in general	5.56	5.59	5.64	5.62	5.58	5.74	5.76	5.61
Home support for achievement in maths	4.17	4.19	4.29	4.30	4.35	4.52	4.47	4.21
Competitive	4.27	4.22	4.19	4.23	4.12	4.35	4.32	4.41
Extroversion	3.99	3.88	3.99	3.91	3.98	4.07	4.03	3.98
Emotional stability	4.04	3.93	4.01	4.03	4.04	3.96	3.99	3.98
Social support	3.07	3.07	3.08	3.20	3.03	3.59	3.36	3.15
Relationship with parents	4.69	4.56	4.68	4.70	4.61	4.59	4.64	4.65
Internality	3.97	3.95	4.05	4.06	4.16	4.30	4.11	3.99
Confidence for all conceptual tasks	2.78	2.79	2.83	2.78	2.72	2.97	2.52	2.87
Confidence for tile conceptual task	2.83	2.86	2.93	2.84	2.78	3.00	2.52	2.99
Confidence for racing car conceptual task	2.69	2.65	2.65	2.67	2.66	2.89	2.58	2.64
Attitudes to all conceptual tasks	3.40	3.30	3.37	3.45	3.28	3.84	3.28	3.34
Attitudes to tile conceptual task	3.52	3.42	3.50	3.56	3.37	4.01	3.40	3.52
Attitudes to racing car conceptual task	3.28	3.20	3.24	3.37	3.16	3.67	3.00	3.17
Q4A 'I intend to continue to study maths after my GCSEs.'	3.70	3.78	4.07	4.10	3.69	4.27	4.04	3.99
Total score in conceptual tasks	5.99	6.43	6.51	5.77	4.12	5.61	3.03	7.63
Score in tile conceptual task	3.01	3.36	3.45	3.02	1.97	3.05	1.53	4.08
Score in racing car conceptual task	2.97	3.07	3.06	2.74	2.15	2.56	1.50	3.55

Table 4: Physics Year 10 (England) student mean response per construct for different FSM bands

Mean results by construct (scale of 1-6) with 6 being high agreement	School FSM band							
	0-5%	5-9%	9-13%	13-21%	21-35%	35-50%	50% +	Grammar
Physics self-concept	3.55	3.48	3.47	3.56	3.46	3.80	3.10	3.52
Perception of physics lessons	3.81	3.77	3.86	3.88	3.84	4.10	3.50	3.66
Attitudes to physics lessons	3.75	3.63	3.72	3.79	3.63	3.89	3.33	3.69
Advice/pressure to study physics	3.33	3.25	3.18	3.39	3.01	3.85	2.54	3.20
Intrinsic perceived value of physics	3.87	3.81	3.96	4.00	3.85	4.20	3.74	3.82
Extrinsic perceived value of physics	3.29	3.25	3.31	3.41	3.29	3.62	3.16	3.17
Students' perceptions of physics teacher	4.29	4.38	4.34	4.32	4.41	4.76	4.03	4.19
Organisational skills	3.84	3.76	3.80	3.84	3.84	4.25	3.76	3.92
Engagement with ICT	3.47	3.53	3.55	3.53	3.57	3.79	3.28	3.46
Global motivations and aspirations	4.61	4.57	4.57	4.63	4.51	5.11	4.59	4.58
Sense of school belonging	4.29	4.17	4.20	4.20	4.14	4.82	4.16	4.30
Home support for achievement in general	5.47	5.56	5.58	5.64	5.53	5.74	5.62	5.59
Home support for achievement in physics	3.95	3.91	3.96	4.14	4.03	4.38	4.06	3.90
Competitive	4.23	4.18	4.20	4.09	4.09	4.36	4.23	4.27
Extroversion	3.98	3.99	4.01	3.93	3.94	4.07	4.02	3.96
Emotional stability	4.04	3.97	3.98	4.06	3.94	4.15	4.07	4.00
Social support	2.80	2.79	2.75	2.85	2.74	3.31	2.62	2.79
Relationship with parents	4.64	4.66	4.60	4.62	4.52	4.91	4.54	4.63
Internality	4.00	4.03	4.10	4.10	4.19	4.39	3.97	3.95
Confidence for all conceptual tasks	2.43	2.41	2.38	2.44	2.45	2.61	2.41	2.53
Confidence for electricity conceptual task	2.45	2.43	2.44	2.48	2.51	2.63	2.48	2.56
Confidence for forces conceptual task	2.39	2.40	2.35	2.39	2.39	2.63	2.35	2.49
Attitudes to all conceptual tasks	3.14	3.07	3.11	3.51	3.16	3.44	2.95	2.95
Attitudes to electricity conceptual task	3.18	3.09	3.15	3.15	3.20	3.43	3.01	2.96
Attitudes to forces conceptual task	3.09	3.04	3.06	4.11	3.08	3.46	2.93	2.96
Q4A 'I intend to continue to study physics after my GCSEs.'	3.05	3.09	3.07	3.30	2.85	3.43	2.60	3.05
Total score in conceptual tasks	4.32	4.28	4.31	4.34	4.19	4.51	3.36	4.77
Score in electricity conceptual tasks	2.19	2.22	2.20	2.23	2.19	2.55	1.17	2.67
Score in forces conceptual tasks	2.21	2.16	2.20	2.24	2.13	2.03	2.24	2.16

Below, we discuss some of the findings regarding our constructs further. Future analysis will look in more detail at the relationship between socio-economic disadvantage and the responses given by heads of department within our school survey in order to explore hypotheses further. At present we note, to varying degrees, a pattern whereby students in certain of the FSM categories consistently manifest a lower average inclination to agree with certain of the constructs (Figure 2).

Figure 2: Average scores for students completing the mathematics questionnaire for selected constructs for different FSM bands (data taken from Table 3)



Intriguingly, the ranking of the 'home support for achievement' category shows a consistent, albeit small, stepwise *reverse* trend in relation to the FSM categories (Table 5).

Table 5: Student scores for home support for achievement in mathematics for different FSM bands

Mean results by construct (scale of 1-6) with 6 being high agreement	School FSM band				
	0-5%	5-9%	9-13%	13-21%	21-35%
Home support for achievement in maths	4.17	4.19	4.29	4.30	4.35

The following findings were most notable.

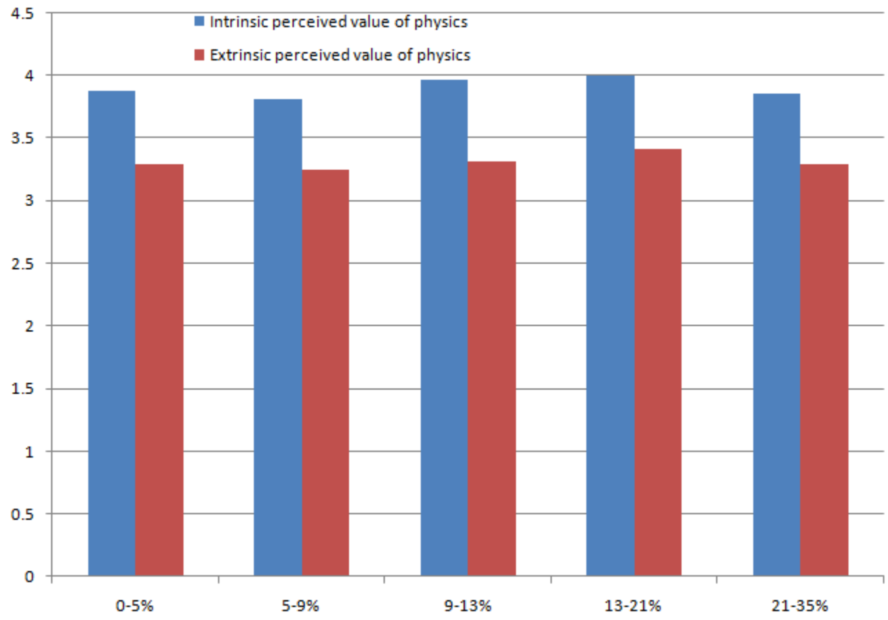
Self concept of mathematics

- There is a tendency for students in the schools in the higher FSM bands to have higher self-concepts, with those in the 9-13% and 13-21% bands being significantly higher than those in the lower two categories.

Perceptions of mathematics and physics

- The intrinsic value of physics[2] was higher, regardless of FSM band, than its extrinsic value (Figure 3).

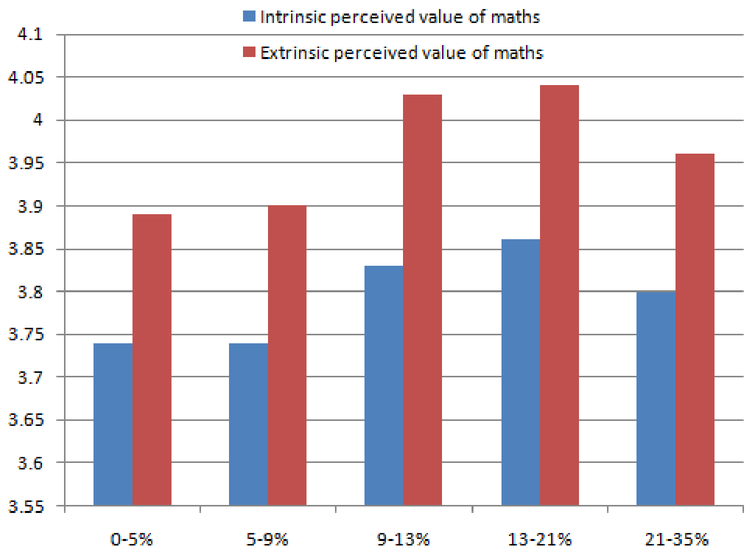
Figure 3: Intrinsic and extrinsic value of physics for students in different FSM bands



- By contrast the intrinsic value of mathematics was lower (regardless of FSM band) than the extrinsic value (Figure 4)[3]. Also, the differences between the perceived intrinsic and extrinsic values are much larger. In addition, there appears to be greater variation amongst the average responses of students in the various FSM categories in relation to the value of mathematics.

Figure 4: Intrinsic and extrinsic value of mathematics for students in different FSM bands

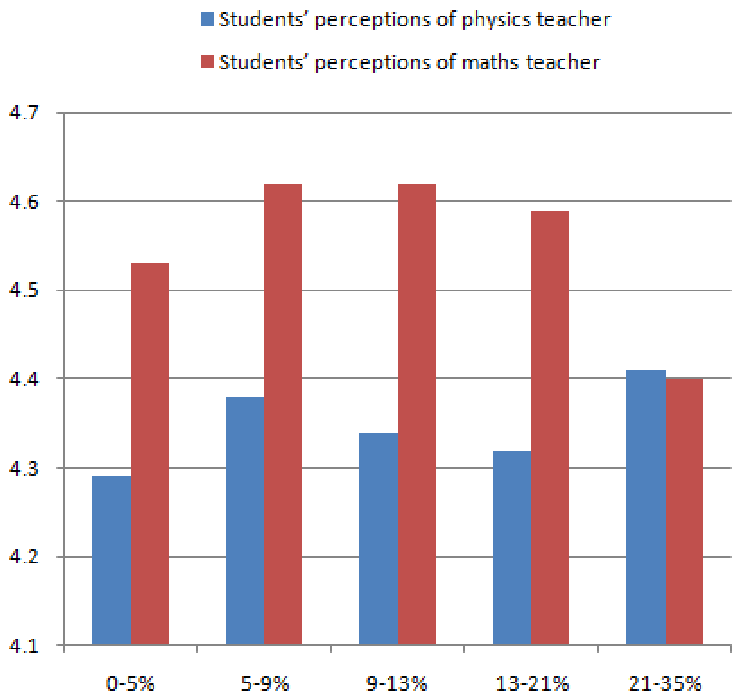
[2] The intrinsic value of a subject is its perceived value in its own right, i.e. where students enjoy the subject for its own sake, as opposed to the extrinsic value which is where students value a subject as a door opener, for financial gain, etc.
[3] This finding supports a similar findings in our BERA Strand 2 paper based on qualitative work



Perceptions of mathematics and physics teachers

- The students' generally rate their mathematics teacher more highly than their physics teacher (Figure 5).

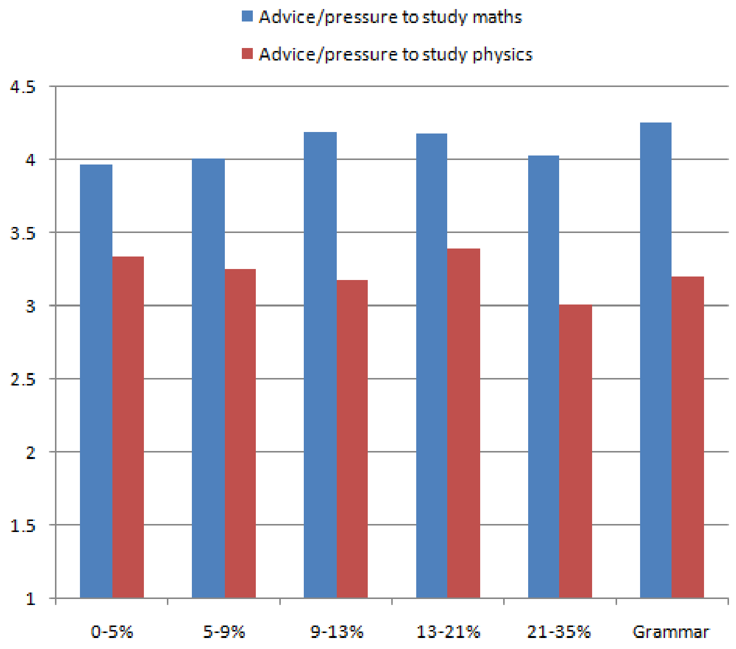
Figure 5: Student ratings of their mathematics and physics teachers for different FSM bands



Advice and pressure to study mathematics and physics

- Students report greater 'Advice and pressure to study' mathematics than physics (Figure 6).

Figure 6: Advice and pressure to study mathematics and physics for students in different FSM bands



3.2 Related to students' intentions to participate in mathematics and physics

The questions regarding intention to participate in mathematics and, separately, in physics post-16 were coded such that a high score represents strong stated intention to participate. Students were more likely to report that they were intending to study mathematics (18.5% in strong agreement) than physics (8.8% in strong agreement) post-16 (Table 6).

Table 6: Intention to participate in mathematics and physics post-16

Question		**Responses (percentages)**					
		Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
Mathematics year 10 (n=5321)	Overall results for England sample	11.1	14.2	10.6	22.0	23.6	18.5
	Boys in England	9.3	11.2	9.3	20.9	26.8	22.4
	Girls in England	12.7	16.6	11.9	22.7	20.9	15.1
Physics year 10 (n=5034)	Overall results for England sample	21.4	23.7	13.1	18.9	14.0	8.8
	Boys in England	17.7	18.1	12.7	19.5	18.7	13.3
	Girls in England	24.9	28.7	13.6	18.4	9.9	4.5

The relationship between intention to participate and gender is consistent with general patterns of participation as reported in many studies within the UK:

- More students reported that they *did not* intend to study physics than mathematics post-16 (21.4% reported strong disagreement about studying physics compared to 11.1% who reported strong disagreement for mathematics).
- In physics, strong agreement in intention to participate is 13.3% for boys and 4.5% for girls.
- In mathematics, the gender bias in intention to participate (measured by strong agreement) is not as large as in physics (22.4% boys versus 15.1% girls).

Table 7 shows the relationship between stated intention to participate in, separately, mathematics and physics, and certain of our core constructs. Rather than commenting on these relationships here we deal with them in Section 3.3 of this paper.

Table 7: Relationship between intention to participate in mathematics/physics and core constructs (* p< 0.05; ** p < 0.01)

Pearson Correlation with intention to study physics		Pearson Correlation with intention to study mathematics	
Perceptions of mathematics/physics			
Self-concept	.458**	Self-concept	.493**
Perception of physics lessons	.362**	Perception of maths lessons	.418**
Attitudes to physics lessons	.495**	Attitudes to maths lessons	.469**
Advice/pressure to study physics	.643**	Advice/pressure to study maths	.674**
Intrinsic perceived value of physics	.448**	Intrinsic perceived value of maths	.489**
Extrinsic perceived value of physics	.589**	Extrinsic perceived value of maths	.537**
Students' perceptions of physics teacher	.260**	Students' perceptions of maths teacher	.227**
Attitudes to all conceptual tasks	.157**	Attitudes to all conceptual tasks	.414**
Attitudes towards learning			
Organisational skills	.319**	Organisational skills	.261**
Engagement with ICT	.098**	Engagement with ICT	.042**
Global motivations and aspirations	.239**	Global motivations and aspirations	.275**
Engagement with extracurricular physics	.269**	Engagement with extracurricular math	.110**
Sociological dimension/support			
Sense of school belonging	.176**	Sense of school belonging	.169**
Home support for achievement in general	.035*	Home support for achievement in general	.130**
Home support for achievement in physics	.286**	Home support for achievement in maths	.327**
Social support	.227**	Social support	.138**
Relationship with parents	.072**	Relationship with parents	.092**
Psychological characteristics			
Internality	.131**	Internality	.152**
Competitiveness	.009	Competitiveness	.050**
Extroversion	-.054**	Extroversion	-.042**

Emotional stability	.079**	Emotional stability	.085**
Engagement with extracurricular physics	.269**	Engagement with extracurricular math	.110**
Conceptual tasks and attainment			
Confidence for all conceptual tasks	.276**	Confidence for all conceptual tasks	.290**
Internality	.131**	Internality	.152**
Total score in conceptual tasks (0-? scale)	.078**	Total score in conceptual tasks (0-11 scale)	.230**
KS2 Total marks achieved in Maths test (sum of Paper A, Paper B and mental arithmetic tests).	-.013	KS2 Total marks achieved in Maths test (sum of Paper A, Paper B and mental arithmetic tests).	.211**
KS2 Total marks achieved in Science test (sum of Paper A and Paper B tests).	.080**	KS2 Total marks achieved in Science test (sum of Paper A and Paper B tests).	.106**
KS2 Total KS2 point score as used in the valued added calculations.	.053**	KS2 Total KS2 point score as used in the valued added calculations.	.080**

3.3 Multi-level analysis: The influence of school and student characteristics on intention to participate post-16 in mathematics/physics

Null model

We fitted a null model with no explanatory variables for our outcome measure Intention to study mathematics post-16. The outcome measure was treated as a continuous variable. Table 8 indicates that in the null model 7.6% of the variation in students' intention to study mathematics post-16 is attributable to differences between secondary schools with the majority of the variation reflecting differences between individual year 10 students. For physics the equivalent figure is 9.1%.

Table 8: Null model showing school and student level variance of year 10 students' intention to study mathematics/physics post-16 in each of our progressive models

	Null model	Complex value added with school level predictors
School level variance estimate (standard error)	M=.199 (.034) P=.242 (.040)	M=.007 (.007) P=.024 (.009)
Student level variance estimate (standard error)	M=2.43 (.048) P=2.404 (.050)	M=1.207 (0.033) P=1.206 (.032)
School level effect	M=7.6% P=9.1%	M=.58% P=.83%
Number of schools	M=113 P=112	M=107 P=94
Number of students	M=5139 P=4820	M=2784 P=2967

M = mathematics data, P = physics data

These quite low values of 7.6% and 9.1%, though not unusual in multilevel models that partition effects to school and student levels, required us to create an approach that focuses more on the within-school component. As there is evidence of school level variation, the use of multilevel analyses to help explore school level contributors can help improve this initial estimation. We have used a variety of models to attempt to identify the school effects on intended participation rates since we are interested in determining the relative contributions of school and student effects.

Complex value added multilevel model

Our complex value added model saw the introduction of further school level influences collected from the UPMAP school survey. We began modelling in a series of stages. In our final models we have found some core differences between mathematics and physics (though findings are tentative and we continue to explore further). The most important finding to note here, relevant to both models, is that students' motivational, psychological and sociological predictors remained significant even after controlling for school level variables. In these final sets of models we found ethnicity and mother's occupation failed to reach significance once we controlled for the student psychological constructs. We also found that the school mathematics and science KS2 mean score lost significance after the introduction of motivational, psychological and sociological items. Gender continued to have a strong influence (boys more likely to express an interest in participation than girls). Measures of socio-economic disadvantage at the student, school and neighbourhood level were never found to be significant even in any of the earlier models.

Mathematics

The complex value added model includes resources available for teachers, heads of department having begun teaching careers after the introduction of the National Curriculum and, finally, the extent to which teachers in school concentrate on developing skills in students for mathematics-related careers (incidental to their teaching). All of these were found to have a significant independent influence and we found that students' psychological and motivational characteristics were also still significant (Table 9).

Table 9: Mathematics year 10 complex value added model

	Background factors	**Intention to study mathematics post-16 Year 10 students**
Student level factors		
Students' psychological and sociological makeup	Mathematics advice pressure to study Mathematics social support Engagement with extra curricular activities in mathematics	+ - +
	Mathematics self concept Intrinsic value Extrinsic value	+ + +
Student background characteristics	Gender [male] Female	 -
Student cognitive tests	Mathematics KS2 (prior attainment)	n/s
School level predictors		

	% FSM at school level	n/s
	Total mark mathematics school level KS2	n/s
Extent teachers in school concentrate on developing in students the skills and knowledge that will help them progress towards mathematics-related careers & feel it is incidental to their teaching	Agree (compared to strongly agreeing) Strongly disagree	- -
	High resources at school for teachers to help with teaching (low resources)	+
Teaching experience	Post national curriculum (pre national curriculum)	+

Notes: n/s = not significant, + = positively significant, - = negatively significant, comparison groups in brackets (male, strongly agree that developing skills in students for maths careers is incidental to teaching).

Physics

For the physics model (reported in Table 10) we used the same variables as with the mathematics one (as we collected the same data). We did not find similar patterns (at the school level) and for physics found that discussion at departmental meetings was negatively associated with post-16 student intention to participate.

Statistically significant similarities at the student level between mathematics and physics models were:

- Gender (boys more likely than girls to express intention to participate)
- Extrinsic value of the subject (high extrinsic appreciation of a subject related to participation)
- Prior attainment at student level (not significant)
- School KS2 score (not significant)
- Self concept (high self concept related to intended participation)
- Engagement with mathematics/physics extra curricular activities related to intended participation
- Advice pressure to study (high pressure related to high intended participation)

Statistically significant differences at the student level were:

- Intrinsic value (high intrinsic appreciation of mathematics related to intended participation)
- Extroversion (being more introverted related to intended physics participation)
- Attitude to lessons (related to intended physics participation)
- Mathematics social support (more support for mathematics related to less participation)
- Focused home support for physics related to intended participation

Table 10: Physics year 10 complex value added model

	Background factors	Intention to study physics post-16 Year 10 students
Student level factors		
Students' psychological and sociological makeup	Physics advice pressure to study Engagement with extra curricular activities in physics	+ +
	Physics self concept Extrinsic value Attitude to lessons Extroversion	+ + + -
Student background characteristics	Gender [male] Female	 -
Student cognitive tests	Physics KS2 (prior attainment)	n/s
	Home support achievement in physics	+
School level predictors		
	% FSM at school level	n/s
	Total mark physics school level KS2	n/s
	Discussion at department meetings	-

4 *Discussion and draft interim findings*

Using a variance components (null model) with no explanatory variables for our outcome measure, intention to study mathematics/physics post-16 demonstrated a low intra-school correlation, thus pointing to relatively low between-school variation[4]. Our intra-school correlation showed that 7.6% of the variation in students' intention to study mathematics post-16 was attributable to differences between secondary schools (9.1% for the equivalent model in physics) but that the majority of the variation reflected differences between *individual* year 10 students. However, there was school level variation, and the multilevel analyses were one approach we adopted to explore school level factors. One of the challenges of estimating school effects is separating school effects from other sources of variability in student participation rates, such as student psychological characteristics, their social background and area deprivation. This is the primary reason why we continue to use a variety of models to attempt to identify the school effects on participation rates. The key advantage of our multilevel models is that they recognise that our students' responses are within a dataset that comes from a common source (each of their schools). Student and school observations are in general not independent and it is important for this project to seek to model this dependency.

Student level influences

[4] The intra-school correlation measures the extent to which the scores of year 10 students as learners of mathematics/physics in the same secondary schools respond similarly to one another as compared to students from different schools.

Student background

Our results indicate that the students' psychological and motivational characteristics are indeed important predictors of intention to study mathematics and physics independent of the influence of school level factors and child background characteristics, although there was variation between schools. We found that students' ethnic group and mother's occupation are important predictors of intention to participate in mathematics/physics though in our final complex value added model, once we accounted for student psychological and motivational characteristics, ethnic group and maternal occupation no longer have any independent influence. Gender was a significant predictor of intention to participate in mathematics and physics in all our models (in favour of boys) even within our final complex value added model that accounted for students' prior attainment and several school level influences as summarised below. Though we controlled for prior attainment in earlier models, this did not have any independent influence. Student level FSM data and neighbourhood deprivation did not have an independent influence on predicting intention to study mathematics or physics. The school level KS2 mathematics score was no longer a significant predictor of intention to participate in mathematics once we controlled for students' psychological and motivational characteristics. We found similar results for physics; school level KS2 science score was initially significant but lost significance for the same reasons. The school level KS2 level mathematics score was not a significant predictor.

Student psychological constructs

We found that students' motivation is an important predictor of intention to study mathematics (both intrinsic and extrinsic motivation), though for physics we find only extrinsic value is significant. Within our final complex value added model we found that the self-concept in mathematics and physics had independent influences (for their respective subjects). Those who were more introverted in nature were more likely to express intended participation in physics but not for mathematics.

Other student level influences

For mathematics and physics we find that engagement with mathematics/physics extra curricular activities and advice/pressure to study these subjects post-16 increases intended participation. For mathematics, social support for mathematics decreases intended participation (no such finding for physics). Positive attitude to physics lessons and home support for achievement in physics is related to intended participation (not for mathematics).

School level influences

School level FSM data did not have an independent influence on predicting intention to study mathematics or physics, mirroring similar findings of FSM at the student level.

Our final complex value added model did, however, indicate that independent of the strong student level characteristics (such as self-concept, motivational and psychological characteristics) there were significant school level influences. Schools that have heads of department who only began teaching after the introduction of the National Curriculum in 1989 are more likely to have students who want to participate in mathematics post-16 (though there is no such finding for physics). We also found that access to resources for teachers was an important predictor of students' intention to participate in mathematics post-16 (though there is no such finding for physics). We also looked at the extent to which teachers in schools concentrated on developing in students the skills and knowledge that would help them progress towards mathematics-related careers. Our findings indicate that those heads of department who focus more on teaching mathematics for post-16 careers are less likely to have students that intend to study in mathematics post-16. We explored this in physics but did not find a significant association.

For physics we found that engagement by teachers in departmental meetings was negatively associated with student expressed intention to participate in physics post-16. One possible reading of this finding is that some schools have managed to hang onto the idea that being a teacher is more about teaching than about being in meetings. Schools where the heads of physics (or science where applicable) focus more on actual classroom practice and devote more time to teaching physics rather than spending time on meetings are perhaps more likely to impart their passion of physics to their students and thus increase intended physics participation. Another possible reading of this is that those schools that have issues with resources and/or pupil achievement/engagement are more likely to have meetings in order to find ways of resolving issues. Therefore this construct could be a proxy for other problems within the school that are impacting students' intention to participate (for those schools that feel they spend a high proportion of their time in meetings). Further interrogation of this data (using both quantitative and qualitative techniques) will help shed further light on this finding.

We intend with all these findings from Strand 1 of our work to interpret these in conjunction with emerging findings from other strands. So, for instance, our findings with mathematics (focusing on post-16 careers in teaching related to decreased intentions to participate) and physics (schools who spend more time in meetings relates to decrease in participation) coincides with qualitative findings for mathematics (presented in our second BERA paper) where we point to a focus on teaching mathematics as an end in itself (a view held by the head of mathematics) has resulted in one particular school having a considerable number of students in one school who value and enjoy mathematics purely for what the subject is rather than what it will do for them post-16. We did not find this in five of our other schools that formed a part of this analysis. The head of mathematics spoke about valuing her role as a classroom teacher above and beyond her role as head of department, which tallies with our multi-level results for physics (more meetings equates to less intended engagement).

As one example, the finding that the student level predictor of social support in mathematics is negatively related to intention to participate when taken in conjunction with the qualitative findings that are emerging was partially expected. Our data in Strand 2 – that follows 15 year-olds (year 10) until they are in year 12 – indicates so far that not all students who have strong social influences to study mathematics or physics necessarily decide to take these subjects further. Some students are reacting against such influences, so much so that we can characterise a core set of our students as *resistant* to family influence. The Strand 1 findings indicate that those students who do not get help for mathematics from various sources are *more* likely to do mathematics post-16, possibly suggesting that they are more likely to study this post-16 because of the lack of perceived pressure (as indicated by our qualitative work) – or it might simply be that the students who are more likely to study mathematics post-16 do not need any additional support from other sources. In any event, this finding is tentative given that another social resource variable 'advice/pressure to study mathematics' has a positive significant influence on studying mathematics post-16. However, the two constructs measure different dimensions of social influence. The latter merely asks who encourages them to study mathematics post-16 whereas the social support one is seeking to uncover to whom students go for help with their mathematics learning. Furthermore, the findings at the school level also somewhat suggest that external pressure may possibly have a negative influence on engagement with mathematics post-16. There was a significant positive relationship between students intending to study mathematics post-16 and less of a focus on teaching mathematics for post-16 careers (as we have highlighted above). We need to do more exploration of this finding but it suggests that teaching mathematics in its own right, rather than teaching it for its exchange value, may be having a positive impact on students wanting to engage with mathematics post-16.

Similarly, our models indicate that motivation, social support and self concept are important predictors of intended participation. Qualitative analysis of narrative and semi-structured interviews in Strand 3 of our work focus on motivations and intentions using either psychoanalytical approaches as a way of uncovering issues around student choice or getting students to talk openly about why they decide to go down a particular educational trajectory (Reiss et al., 2010; Rodd et al., 2010). It is clear that survey data alone are at times not enough to elucidate issues around choice.

References

Mujtaba, T., Hoyles, C., Reiss, M., Riazi-Farzad, B., Rodd, M., Simon, S. & Stylianidou, F. (2009). Factors that influence post-16 participation in mathematics and physics. Presented at the 13th international conference at EARLI. Amsterdam 24th – 31st August 2009.

Reiss, M., Hoyles, C., Mujtaba, T., Riazi-Farzad, B., Rodd, M., Simon, S. & Stylianidou, F. (2010). Under review.

Rodd, M., Mujtaba, T. & Reiss, M. (2010) Participation in mathematics post-18: undergraduates' stories, (2010) *Proceedings of the British Society for Research into Learning Mathematics*, 30, 175-182.

Acknowledgements

Very many thanks to our discussant Pam Sammons, ESRC, to members of the UPMAP Advisory Committee and to all those students and teachers who contributed data.